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Pruitt et al.

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(54) **SHIFTED ANGLE FABRIC**

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(22) Filed: **Sep. 13, 2012**

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(51) **Int. Cl.**

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D06C 3/08	(2006.01)
D03D 1/00	(2006.01)
D03D 7/00	(2006.01)
D06B 1/00	(2006.01)
D06C 7/00	(2006.01)

(52) **U.S. Cl.**
CPC ***D06C 3/08*** (2013.01); ***D03D 1/0005*** (2013.01); ***D03D 7/00*** (2013.01); ***D06B 1/00*** (2013.01); ***D06C 7/00*** (2013.01)

(58) **Field of Classification Search**
CPC D03D 13/002; Y10T 442/3179
USPC 442/203, 208
See application file for complete search history.

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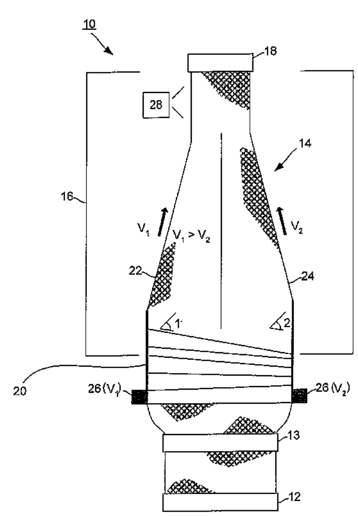
(57) **ABSTRACT**

An apparatus and method for producing a shifted angle fabric and the product produced thereby. The apparatus includes a supply of fabric and a differential tenter frame. The differential tenter frame includes a frame, a pair of opposed, constant path rails and a differential drive. The differential tenter frame is located downstream from the supply of fabric for receiving the opposing edges of the fabric and advancing the opposing edges at different speeds to shift the weft angle of the fabric as the fabric travels the length of the differential tenter frame. A high velocity, low heat drying range adjacent to the differential tenter frame simultaneously dries the fabric as the fabric travels the length of the differential tenter frame. A take-up roll downstream from the differential tenter frame then takes up the dried fabric.

7 Claims, 8 Drawing Sheets



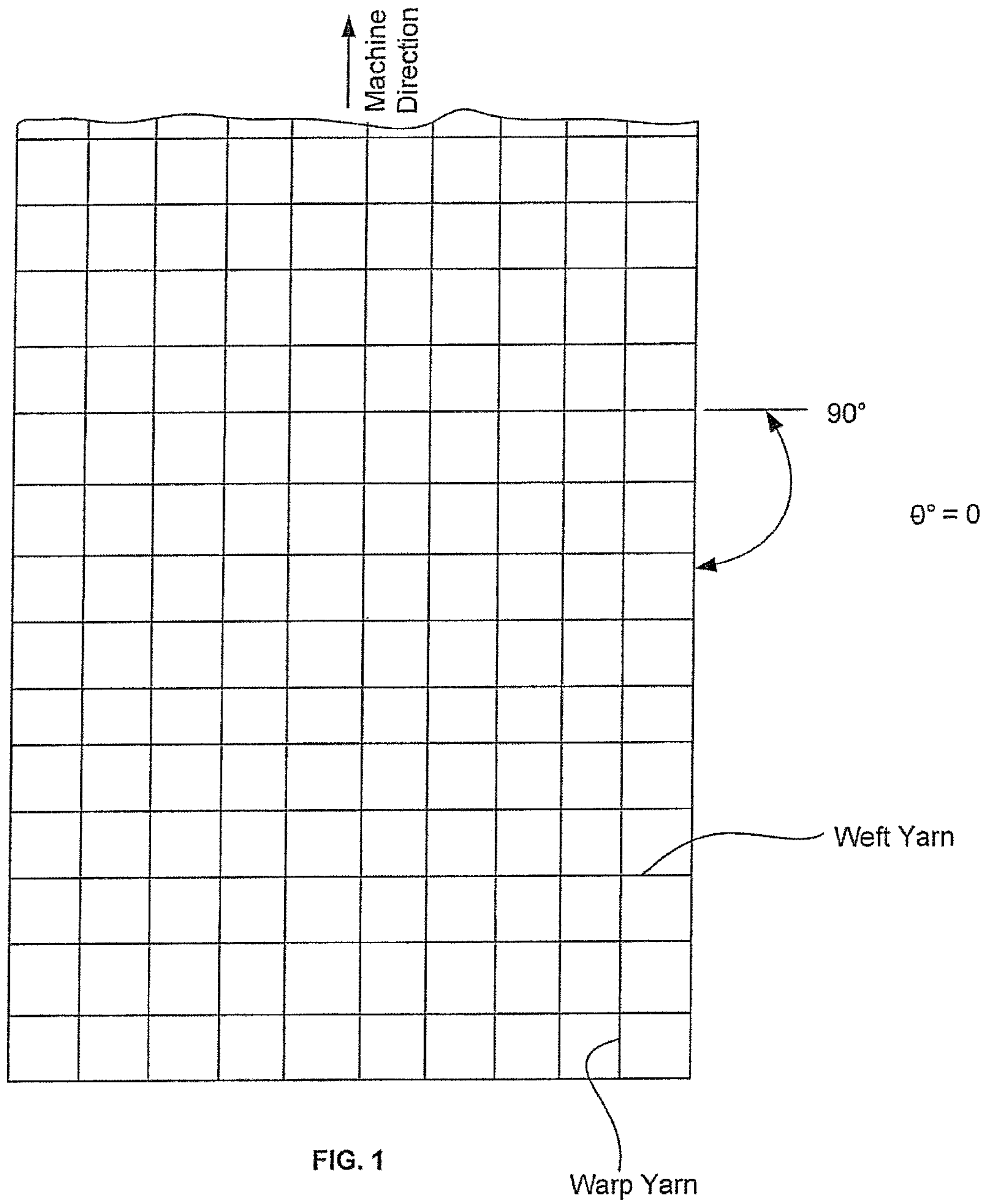


FIG. 1

--PRIOR ART--

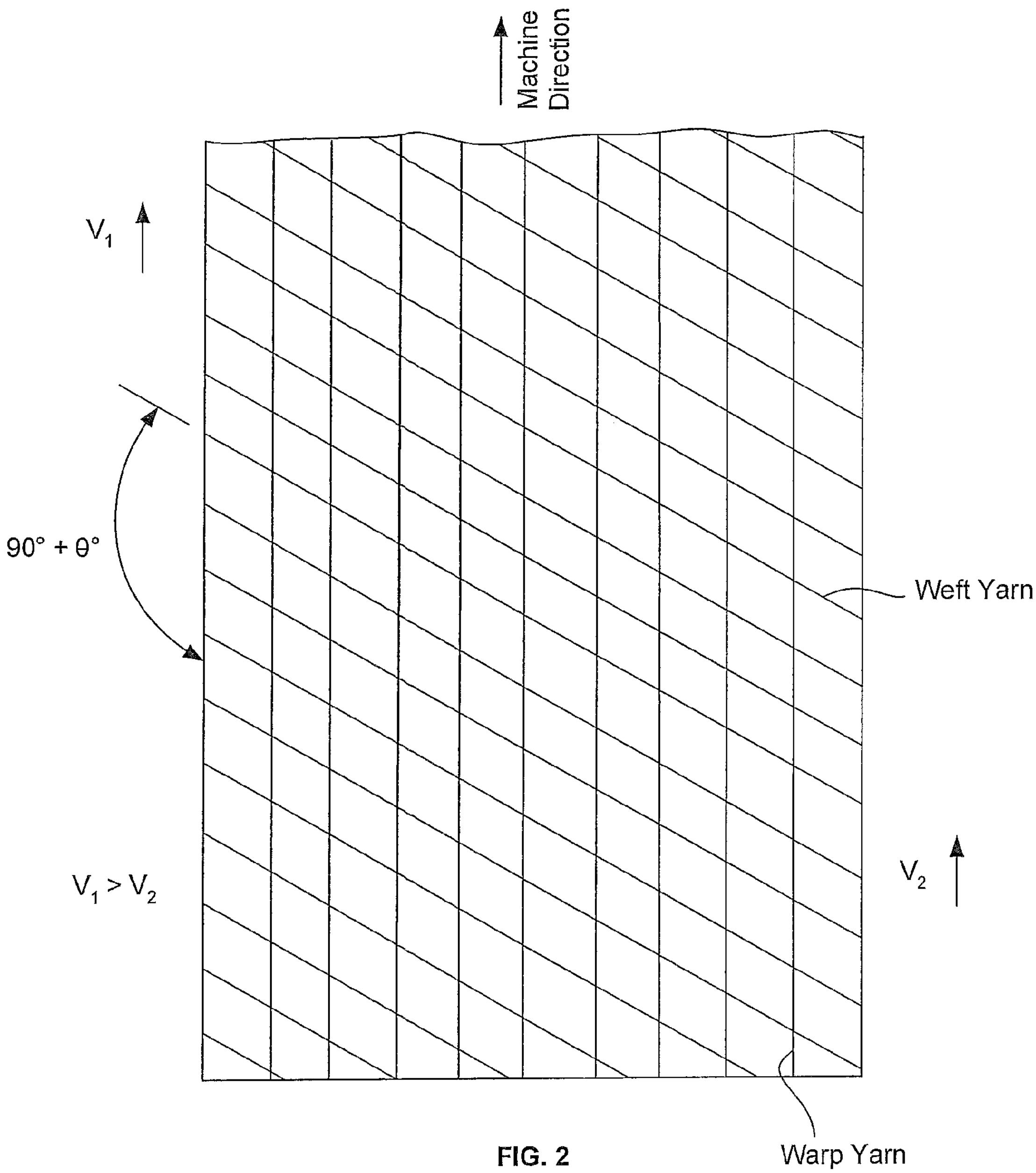
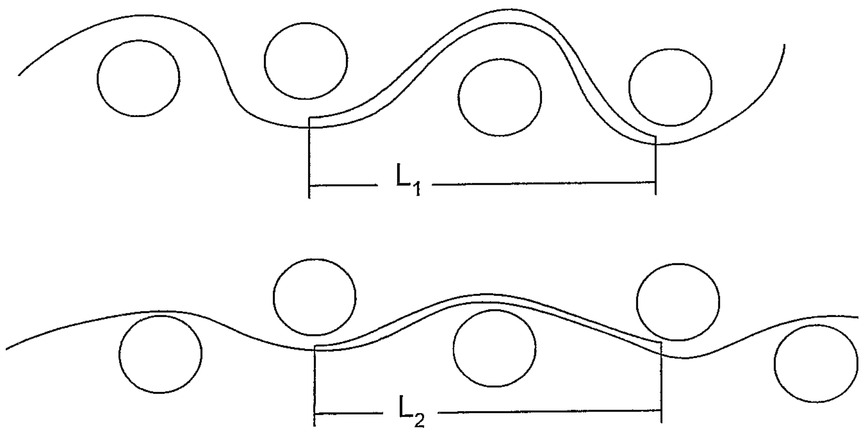


FIG. 2



$C_1 < C_2$ in Warp

FIG. 3

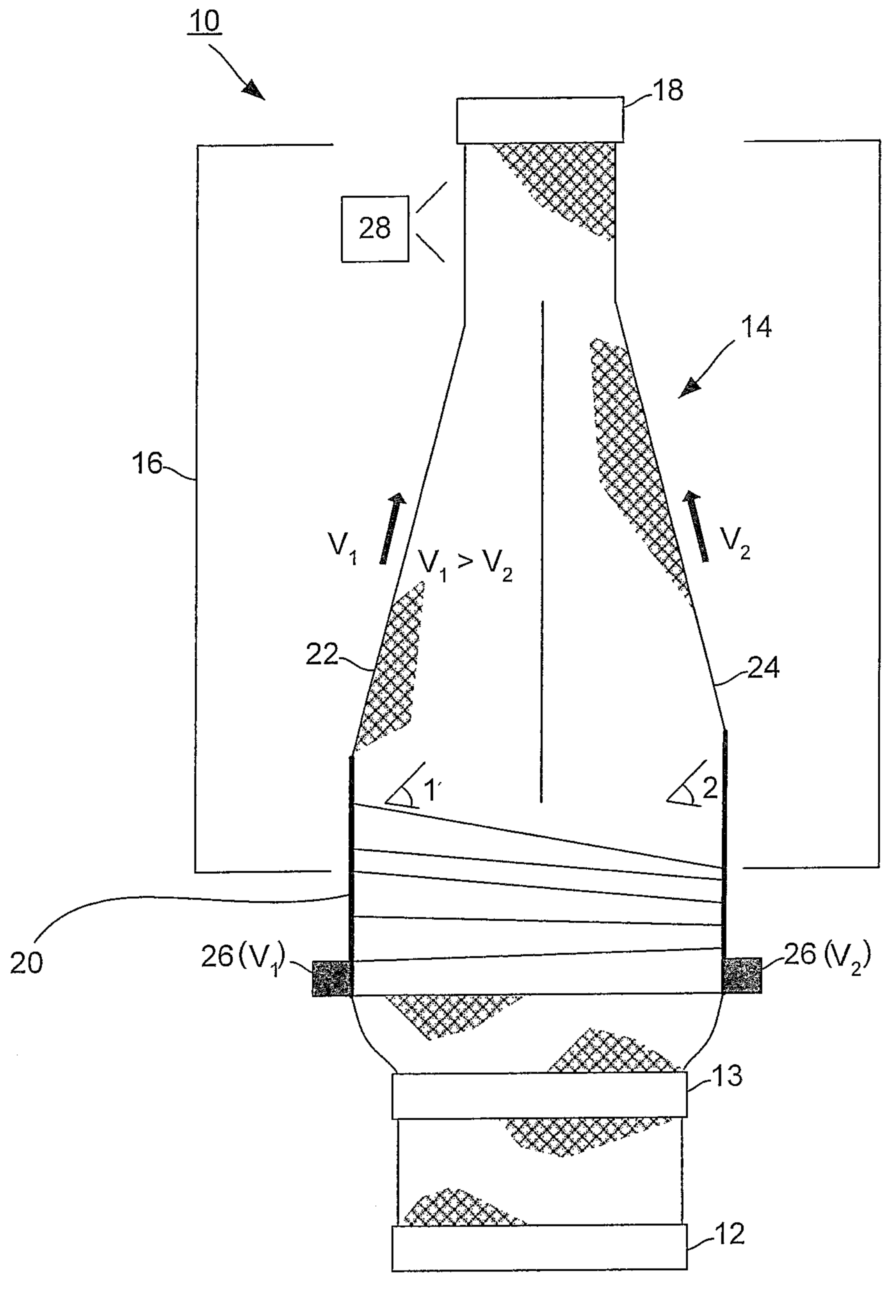


FIG. 4

FIG. 5

(Drying / % Rebound)

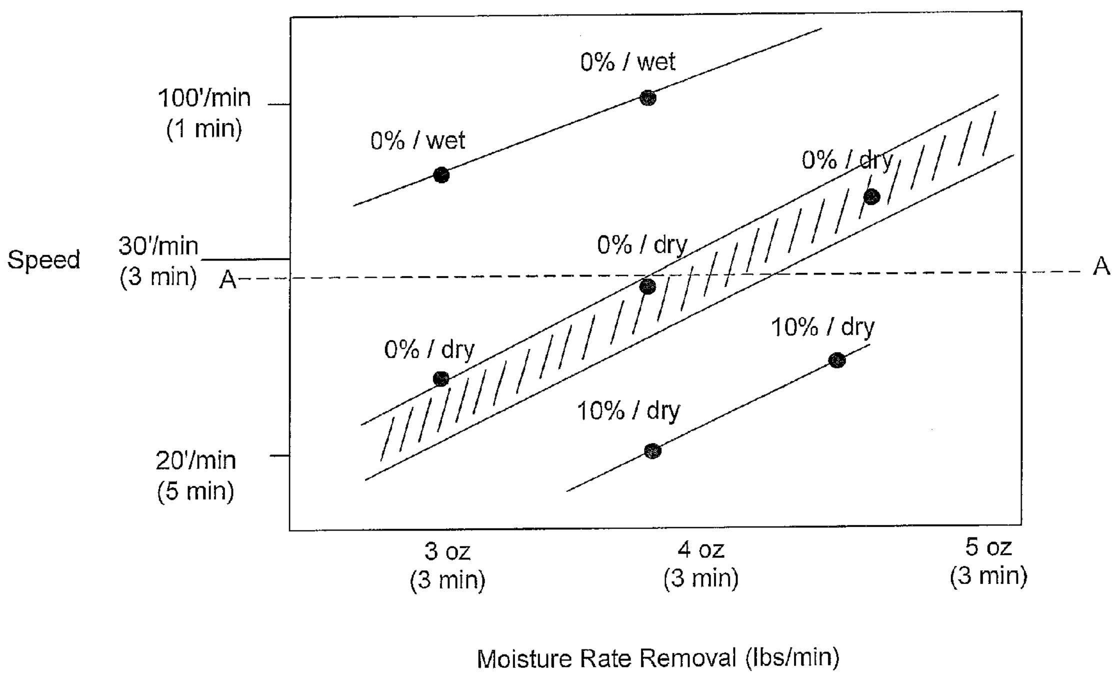
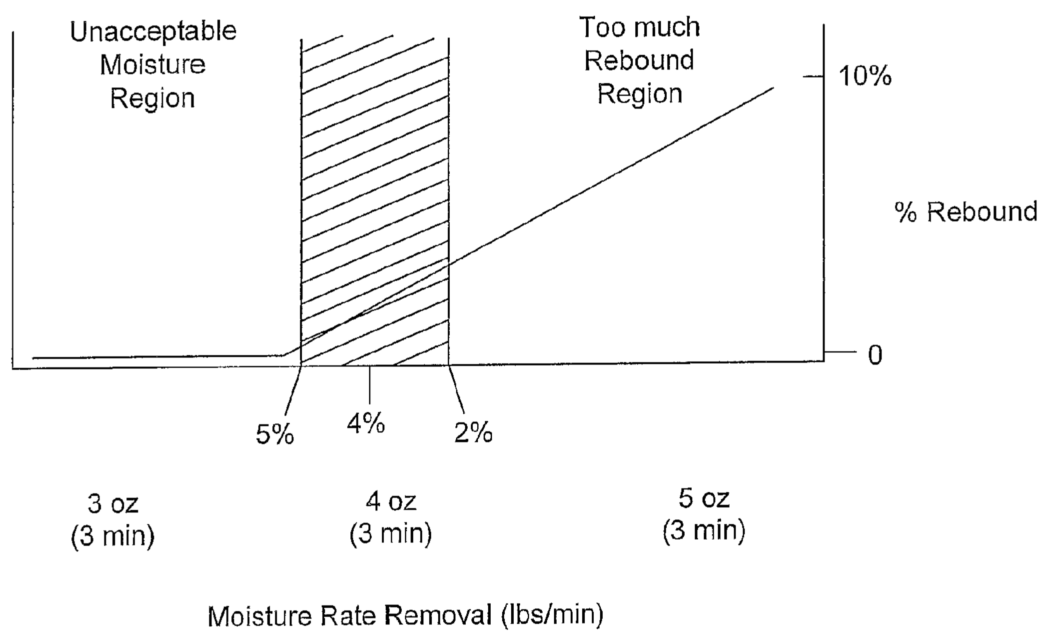


FIG. 6


Unacceptable Moisture Region
Too much Rebound Region
10%
% Rebound
0
5%
4%
2%
3 oz (3 min)
4 oz (3 min)
5 oz (3 min)
Moisture Rate Removal (lbs/min)

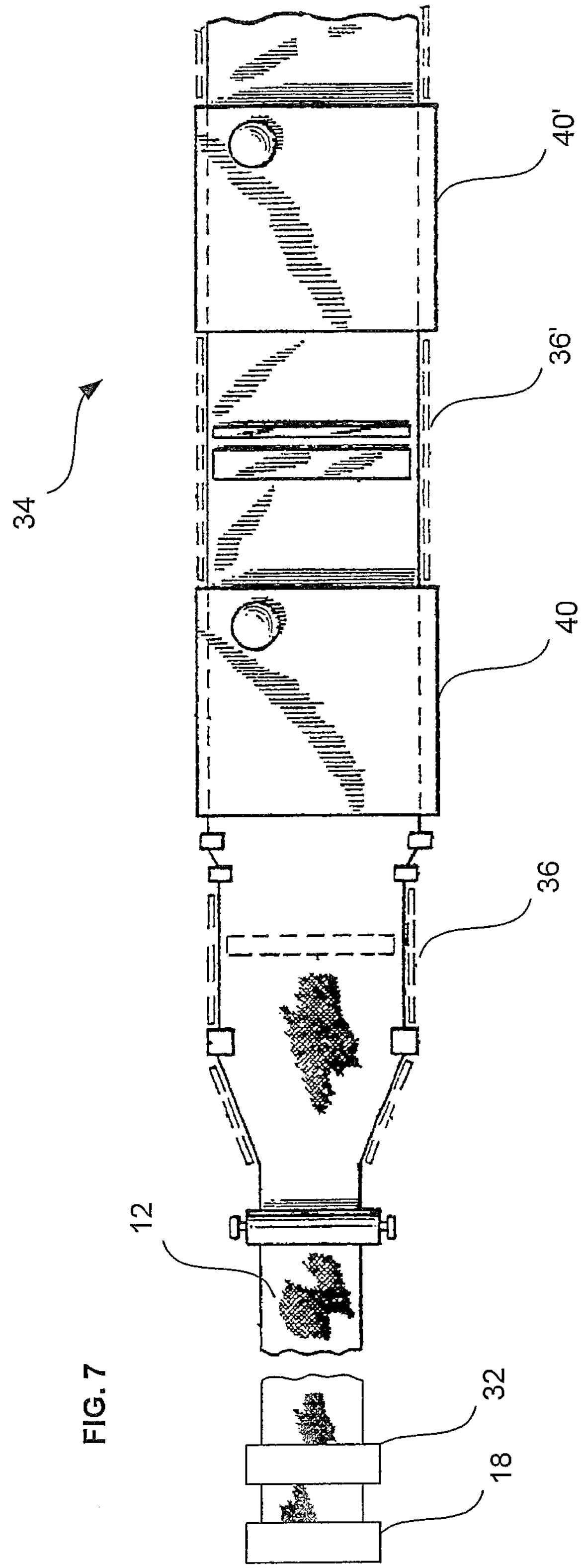


FIG. 7

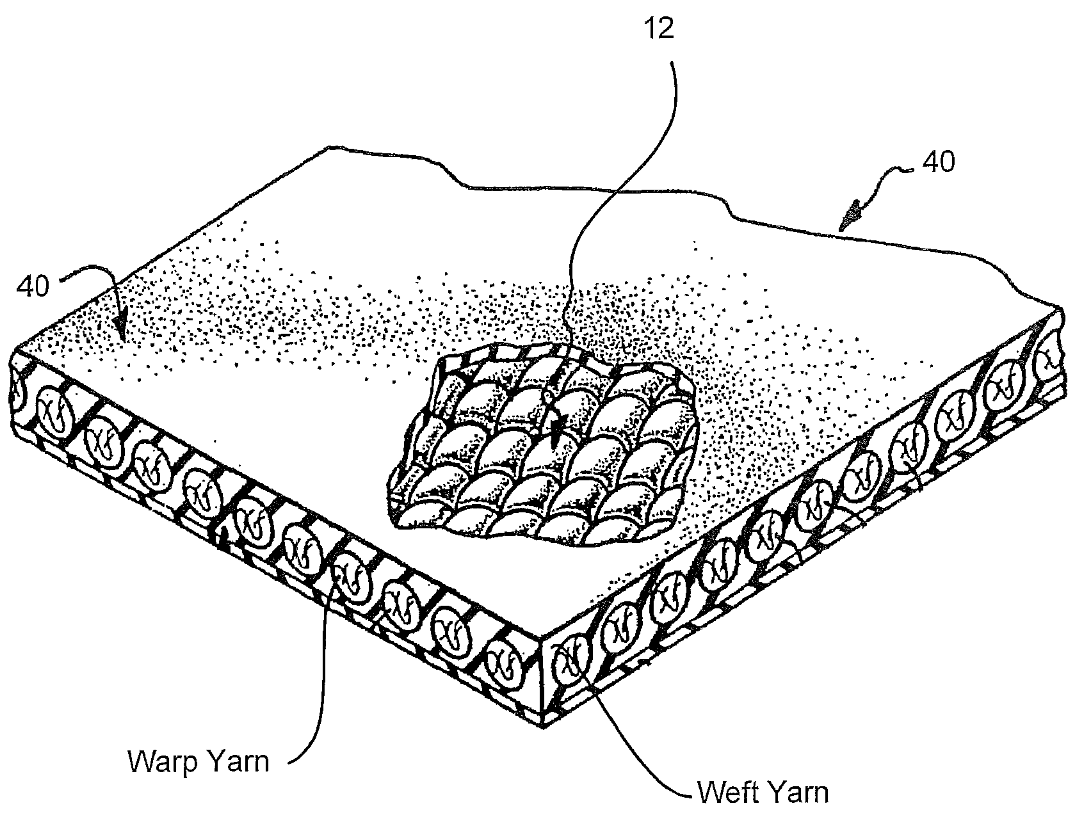


FIG. 8

SHIFTED ANGLE FABRIC

This application is a divisional of application Ser. No. 12/553,154 filed Sep. 3, 2009, now U.S. Pat. No. 8,296,911 issued Oct. 30, 2012.

BACKGROUND OF THE INVENTIONS

(1) Field

The present inventions relate generally to an apparatus for producing a shifted angle fabric and, more particularly, to an apparatus and method for producing a shifted angle fabric having balanced crimp and the product produced thereby.

(2) Related Art

Conventional woven fabrics are produced with lengthwise warp yarns and crosswise weft yarns interlaced at an angle of 90 degrees. For some applications, including power transmission belts, tires, and hoses, it is useful to rotate the fabric by cutting diagonally and turning the cut panels so that the warp and weft yarns are disposed at ±45 degrees relative to the longitudinal axis of the product. This biased fabric will exhibit increased elongation under load compared to the original fabric orientation.

It has previously been found that, prior to biasing, the elongation properties can be further increased by altering the angle of the warp/weft yarns from the as-woven 90/90 degrees (e.g. 110/80 degrees or 120/70 degrees) by shifting the weft yarn while keeping the warp yarn in its original straight and parallel orientation. The shifted angle fabric is then cut and turned using the conventional biasing techniques so that the obtuse angle is oriented in the machine direction, thereby increasing the elongation properties of the fabric when placed under load. This shifting process has been conducted using various methods so that one selvage of the woven fabric is advanced relative to the opposite selvage.

One commonly used method involves passing wetted-out woven fabric over one or more pairs of angled and tapered rollers followed by drying the fabric on a conventional clip-tenter frame through a dryer. This method typically produces a shifted angle fabric with substantially unbalanced crimp and elongation properties in the warp yarn direction compared to the weft yarn direction. Additionally, shifted angle fabric produced by this method will exhibit an undesirable variation in warp yarn crimp and elongation when comparing measurements taken at different points across the width of the fabric, and variation in warp-weft crossover angle measured at different points across the width of the fabric.

Another method involves use of a specially built tenter frame and dryer with rails arranged in a laterally curved path. The equipment used in this method must be custom made at considerable expense, and cannot be used for processing other types of fabrics.

Thus, there remains a need for a new and improved apparatus which is adapted to produce a shifted angle fabric while, at the same time, producing balanced crimp and the product produced thereby.

SUMMARY OF THE INVENTIONS

The present inventions are directed to an apparatus and method for producing a shifted angle fabric and the product produced thereby. The apparatus includes a supply of fabric and a differential tenter frame. The differential tenter frame includes a frame, a pair of opposed, constant path rails and a differential drive. The differential tenter frame is located downstream from the supply of fabric for receiving the opposing edges of the fabric and advancing the opposing edges at different speeds to shift the weft angle of the fabric as the fabric travels the length of the differential tenter frame. A high velocity, low heat drying range adjacent to the differential tenter frame simultaneously dries the fabric as the fabric travels the length of the differential tenter frame. A take-up roll downstream from the differential tenter frame then takes up the dried fabric.

Preferably, the differential tenter frame is a pin tenter. Also, preferably the differential drive is a variable speed differential drive. The variable speed differential drive may include an AC convertor control system for controlling the speed of the drive.

The differential drive preferably provides a speed differential wherein one opposing edge is between about 25% and about 100% of the width of the fabric trailing the other opposing edge, whereby a shifted angle between about 105° and about 135° is formed. Preferably, the differential drive provides a speed differential wherein one opposing edge is between about 35% of the width of the fabric trailing the other opposing edge whereby a shifted angle between about 1100 is formed.

Preferably, the high velocity, low heat drying range dries the fabric to between about 1 wt. % and about 5 wt. % at the exit from the range. Most preferably, the high velocity, low heat drying range dries the fabric to between about 4 wt. % and about 5 wt. % at the exit from the range. A moisture sensor may be located adjacent to the exit of the high velocity, low heat drying range for measuring the weight percent moisture of the fabric as it exits the range.

The apparatus may further include a trimming station upstream of the take-up roll and downstream from the differential tenter frame. In addition, the apparatus may further include a coating range downstream from the take-up roll. The coating range preferably includes a nip roll assembly, which applies a Resorcinol-Formaldehyde-Latex (RFL) coating to the fabric.

The fabric preferably is a woven fabric and, most preferably, the fabric is a cotton/synthetic blend. The cotton/synthetic blend may be between about 30/70 and about 55/45 cotton/synthetic. Preferably, the blend is about 55/45 cotton/synthetic. Also, preferably, the cotton/synthetic blend is a cotton/nylon blend.

The woven fabric preferably is a square weave construction. Preferably, the square weave is about a 36 by 36 square weave construction.

A fixative may be used to stabilize the fabric. Preferably, the fixative is applied by treating the yarn of the fabric with starch. Most preferably, the starch fixative is associated with yarn in the warp. The starch fixative is re-wetable to allow the fabric to move as the fabric travels the length of the differential tenter frame and thereby ties the warp and weft yarns together as the fabric is dried.

The above apparatus produces a shifted angle woven fabric, wherein the fabric is shifted between about 110 degrees and about 125 degrees and wherein the crimp of the fabric is substantially equal in both the warp and weft directions. Preferably, the fabric is shifted about 112 degrees.

Preferably, the ratio of warp crimp to weft crimp of the fabric is between about 0.5 and about 1.5 when crimp is measured according to ASTM-3883:1990. Preferably, the ratio of warp crimp to weft crimp of the fabric is about 0.9. Also, preferably the crimp of the fabric is between about 3% and about 10% in both the warp and weft directions.

The elongation value of the fabric preferably is between about 35% and about 55% when tested according to ASTM-5034:1995. Preferably, the elongation value of the fabric is about 55%.

Accordingly, one aspect of the present inventions is to provide an apparatus for producing a shifted angle fabric, the apparatus including: (a) a supply of fabric; (b) a differential tenter frame downstream from the supply of fabric for receiving the fabric and advancing the opposing edges of the fabric at different speeds to shift the weft angle of the fabric as the fabric travels the length of the differential tenter frame; and (c) a drying range for simultaneously setting the fabric at the shifted weft angle of the fabric as the fabric travels the length of the differential tenter frame.

Another aspect of the present inventions is to provide an apparatus for producing a shifted angle fabric from a supply of pre-formed fabric, the apparatus including: (a) a differential tenter frame including (i) a frame, (ii) a pair of opposed, constant path rails and (iii) a differential drive, the differential tenter frame located downstream from the supply of fabric for receiving the opposing edges of the fabric and advancing the opposing edges at different speeds to shift the weft angle of the fabric as the fabric travels the length of the differential tenter frame; and (b) a high velocity, low heat drying range for simultaneously drying the fabric as the fabric travels the length of the differential tenter frame.

Another aspect of the present inventions is to provide an apparatus for producing a shifted angle fabric, the apparatus including: (a) a supply of fabric; (b) a differential tenter frame including (i) a frame, (ii) a pair of opposed, constant path rails and (iii) a differential drive, the differential tenter frame located downstream from the supply of fabric for receiving the opposing edges of the fabric and advancing the opposing edges at different speeds to shift the weft angle of the fabric as the fabric travels the length of the differential tenter frame; (c) a high velocity, low heat drying range for simultaneously drying the fabric as the fabric travels the length of the differential tenter frame; and (d) a take-up roll downstream from the differential tenter frame for taking up the dried fabric.

Another aspect of the present inventions is to provide a method for producing a shifted angle fabric, the method including the steps of: supplying a fabric; receiving the fabric and advancing the opposing edges of the fabric at different speeds to shift the weft angle of the fabric; and simultaneously setting the fabric at the shifted weft angle of the fabric.

Still another aspect of the present inventions is to provide a shifted angle woven fabric, wherein the fabric is shifted between about 110 degrees and about 125 degrees and wherein the crimp of the fabric is substantially equal in both the warp and weft directions.

These and other aspects of the present inventions will become apparent to those skilled in the art after a reading of the following description of the preferred embodiment when considered with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** represents a plain weave fabric wherein the warp and weft of yarns are intersecting orthogonally with one another;

FIG. **2** represents the fabric in FIG. **1** after the fabric angles have been shifted;

FIG. **3** is a schematic representation illustrating crimp in the warp yarns caused by conventional distortion using constant speed/variable distance, rollers or rails;

FIG. **4** is a general plan view of a differential tenter frame and drying range for an apparatus constructed according to the present inventions;

FIG. **5** is a graphical representation of a response surface illustrating rebound/wetness as a function of tenter-frame speed (ft/min) and moisture rate removal (lbs/min);

FIG. **6** is a graphical representation taken along line A-A of FIG. **5** at a tenter frame speed of 30 ft/min illustrating the percent rebound/wetness as a function of moisture rate removal (lbs/min);

FIG. **7** is a general plan view of the shifted angle fabric coating range downstream of the apparatus shown in FIG. **4**; and

FIG. **8** is a fragmentary view of a coated shifted angle fabric formed according to the present inventions.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description, like reference characters designate like or corresponding parts throughout the several views. Also in the following description, it is to be understood that such terms as "forward," "rearward," "left," "right," "upwardly," "downwardly," and the like are words of convenience and are not to be construed as limiting terms.

Referring now to the drawings in general and FIG. **1** in particular, it will be understood that the illustrations are for the purpose of describing a preferred embodiment of the inventions and are not intended to limit the inventions thereto. As best seen in FIG. **1**, there is shown a plain weaved fabric wherein the warp and weft yarns are intersected orthogonally with respect to one another. This is a conventional construction used for many textile articles because of its flexibility and patterns and choice of both warp and weft yarns.

For some applications including power transmission belts, tires and hoses, it is useful to rotate the fabric by cutting diagonally and turning the cut panels so that the warp and weft yarns are disposed at ±45 degrees relative to the longitudinal axis of the product. This biased fabric will exhibit increased elongation under load compared to the original fabric orientation. It has previously been found that, prior to biasing, elongation properties can be increased by altering the angle of the warp/weft yarns from the as-woven 90/90 degrees (e.g., 110/80 degrees or 120/70 degrees) by shifting the weft yarn, while keeping the warp yarn in its original straight and parallel orientation with respect to the machine direction (i.e. warp yarn angle with respect to machine direction remains substantially zero) as best seen in FIG. **2**.

Because the warp yarn angle remains substantially zero, the shifted angle fabric can be further processed, if desired, by equipment which can not normally be used to process shifted angle fabric. For example, calendaring a conventional shifted angle fabric, in which the warp yarns are not substantially zero with respect to machine direction, will damage the rubber coated fabric as the warp yarns in the coated fabric try to align themselves with respect to the machine direction of the calendaring machine.

However, as seen in FIG. **2**, the warp yarns of a shifted angle fabric produced according to the present inventions is aligned in the machine direction and, therefore, can be coated and calendered without damage. After calendaring, the coated shifted angle fabric can be cut and turned using conventional biasing techniques so that the obtuse angle is oriented in the machine direction, thereby increasing the elongation properties of the fabric when placed under load.

As can be further appreciated from FIG. **3**, moving either the edges of the fabric, a portion of the fabric or the entire width of the fabric at different distances using unequal length rails or angled and tapered rollers produces unbalanced warp and weft yarn crimp (i.e. C1<C2 in warp) and elongation in a shifted angle fabric. It also can produce varying warp yarn crimp and elongation across the width of the shifted angled fabric. This also may result in a varying warp-weft crossover angle that can be caused by shifting angle of the fabric along a curved weft yarn path. Such variations introduce other variations in subsequent handling of the shifted angle fabric and in the processing of the shifted angle fabric. This often produces variations in physical properties of the final products produced from such fabrics even when the fabric is cut from the same roll because of the variations occur over the width of the fabric and not just along the length of the fabric.

Turning to FIG. **4**, there is shown a general plan view of an apparatus constructed according to the present inventions, generally designated **10**. The apparatus **10** includes a differential tenter frame **14** and drying range **16**. A supply of pre-woven fabric **12** is overfed into differential tenter frame **14** and subsequently dried by the high velocity, low heat drying range **16** prior to being taken up by take-up roll **18**.

The differential tenter frame **14** is a modified, conventional straight pin/tenter frame and includes a frame **20**, a pair of opposed rails **22**, **24** and a differential drive **26**. The differential tenter frame **14** provides lengthwise overfeed capacity. The differential drive **26** provides independent drive control of each of the opposing tenter chains along rails **22**,**24**. In addition, the opposing rails **22**,**24** are adapted to taper towards one another to reduce the distance (width) between the rails **22**,**24** as the fabric progresses along the length of the differential tenter frame **14**. This is important because as the fabric is shifted and the angle of the weft yarns increases with respect to the warp yarns, the distance between the rails **22**,**24** must be closer together to allow the weft yarns to bridge this distance and to maintain control of the tension of the weft yarns.

Preferably, the differential drive **26** is a variable speed differential drive. The variable speed differential drive may include an AC convertor control system for controlling the speed of the drive.

The differential drive **26** preferably provides a speed differential wherein one opposing edge is between about 25% and about 100% of the velocity of the fabric trailing the other opposing edge, whereby a shifted angle between about 105 degrees and about 135 degrees is formed. Preferably, the differential drive **26** provides a speed differential, wherein one opposing edge is about 35% of the velocity of the fabric trailing the other opposing edge, whereby a shifted angle of about 110 degrees is formed.

In operation, the weft yarns are shifted by advancing one selvage of the fabric faster relative to the opposing selvage of the fabric, by driving one tenter chain at a faster speed than the opposing tenter chain. Fabric overfeed capability, combined with the width taper of the tenter rails **22**,**24** allows for precise control of warp and weft yarn crimp and elongation. At the same time, control of the drying range **16** with respect to the speed of the differential tenter frame **14** allows for simultaneous shifting of the weft yarns and drying or setting of the shifted angle fabric as the fabric progresses through the tenter/dryer combination, thereby eliminating the need for separate shifting and drying equipment. The interplay between the tenter frame speed and dryer moisture removal rate as will be better understood by the discussion of the graphs shown in FIGS. **5** and **6** below.

Preferably, the high velocity, low heat drying range **16** dries the fabric to between about 1 wt. % and about 5 wt. % at the exit from the range. Most preferably, the high velocity, low heat drying range **16** dries the fabric to between about 4 wt. % and about 5 wt. % at the exit from the range. A moisture sensor **28** may be located adjacent to the exit of the high velocity, low heat drying range **16** for measuring the weight percent moisture of the fabric as it exits drying range. One suitable sensor is a Model 9900 moisture senor available from Strandberg Engineering Laboratories, Inc. of Greensboro, N.C.

Turning first to FIG. **5**, there is shown a graphical representation of a response surface illustrating rebound/wetness as a function the speed (ft/min) of differential tenter frame **14** and moisture rate removal (lbs/min) of the high velocity low heat drying range **16**. As can be seen from the response surface shown in FIG. **5**, there is a very narrow range of both speed and moisture rate removal, wherein the shifted angle fabric is sufficiently dry that it may be taken up without the problems of mildew and mold caused by excessive moisture. But, at the same time, not so dry that the shifted angle fabric is dried prior to coming to the end of the differential tenter frame **16**. As can be appreciated, if the shifted angle fabric is dried too early while its selvage is still moving at two different speeds, rebound will be introduced into the fabric. Such fabrics will try to return to the lower shifted angle that it was set at when dried, instead of remaining at the angle that it was taken off of the differential tenter frame **14**.

For illustrative purposes, the graph in FIG. **6** shows the results at a constant speed of 30 ft/min for a 100 foot differential tender frame **14** taken along the line A-A of FIG. **5**. For most applications a moisture content of about 4 wt. %±1 wt. % is satisfactory. Below that moisture value, the percent rebound of the shifted angle fabric increases rapidly since the shifted angle fabric is becoming set by the drying progresses. Thus, there is only a very narrow set of operating conditions for the differential tenter frame **14** and the drying range **16** that will produce both acceptable dryness and low rebound in the shifted angle fabric.

After being taken up on take-up roll **18**, the shifted angled fabric is further processed as shown in FIG. **7**. FIG. **7** is a generally conventional coating range such as described in U.S. Pat. Nos. 4,570,566, 4,501,771 and 4,753,823, which are hereby incorporated by reference in their entirety. FIG. **7** may include a trimming station **32** upstream of coating range **34**. Trimming station **32** which also may be located upstream of take-up roll **18** if desired. Coating range **34** is located downstream of take-up roll **18** and trimming station **32** for receiving of the shifted angled fabric and passing it through one or more nip roll coater assemblies **36**, **36'** which apply a Resorcinol-Formaldehyde-Latex (RFL) coating **38** to the fabric. Cure ovens **40**, **40'** downstream of each coater assemblies **36**, **36'** dry the RFL coating **38**. A single coater assembly **36** may also be used for some applications.

The fabric which is produced according to the present inventions is preferably a woven fabric. Preferably, the fabric is a cotton/synthetic blend. The cotton/synthetic blend may be between about 30/70 and about 55/45 cotton/synthetic. Preferably, the blend is about 55/45 cotton/synthetic. Also, preferably, the cotton/synthetic blend is a cotton/nylon blend.

The woven fabric preferably is a square weave construction. Preferably, the square weave is about a 36 by 36 square weave construction.

Furthermore, a fixative may be used to stabilize the supply of pre-woven fabric **12** prior to shifting the angle of the fabric and a portion may remain on the shifted angle fabric after drying to provide additional stability during subsequent handling and processing. Preferably, the fixative is applied by treating the yarn of the fabric with starch. Most preferably, the starch fixative is associated with yarn in the warp. The starch fixative is re-wetable as the fabric is overfed into differential tenter frame **14** to allow the weft yarns of the fabric to move as the fabric travels the length of the differential tenter frame **14** and thereby may be used to tie the warp and weft yarns together as the fabric is dried.

Finally, turning to FIG. **8** there is shown a fragmentary view of a coated shifted angled fabric construction according to the present inventions. The above described apparatus produces a shifted angle woven fabric, wherein the fabric is shifted between about 110 degrees and about 125 degrees and wherein the crimp of the fabric is substantially equal in both the warp and weft directions. Preferably, the fabric is shifted about 112 degrees.

Preferably, the ratio of warp crimp to weft crimp of the fabric is between about 0.5 and about 1.5 when crimp is measured according to ASTM-3883-90 (1990). Preferably, the ratio of warp crimp to weft crimp of the fabric is about 0.9. Also, preferably the crimp of the fabric is between about 3% and about 10% in both the warp and weft directions.

The elongation value of the fabric preferably is between about 35% and about 55% when tested according to ASTM-5034-95 (1995). Preferably, the elongation value of the fabric is about 55%.

Thus, the present inventions provide for the use of a modified, conventional straight-path tenter frame which reduces equipment expense and improves the versatility of the equipment since it can produce a wide range of shifted angle fabrics without requiring changing rails or rollers but by changing the relative speeds of edges of the fabric in the differential tenter frame **14** and by adjusting the width between opposing rails **22**,**24**. In addition, simultaneous shifting and drying/setting of the fabric allows for precise control of warp-weft angle as well as warp and weft yarn crimp and elongation balance. Also, constant control of weft tension by controlling the width between opposing rails **22**,**24** during the shifting process, eliminates curved weft yarn and the resulting variation in warp-weft angle. Finally, gradual skewing of the weft yarn over the considerable length of the tenter frame **16** as compared to prior art curved rails or tapered rollers, reduces side-to-side variation in warp yarn crimp and elongation to a negligible level.

As a result of being able to balance the crimp between the weft and warp yarns in the shifted angle fabric, belting and similar products produced according to the present inventions have been found to track much better than products constructed from shifted angle fabric having unbalanced crimp between the weft and yarns.

Certain modifications and improvements will occur to those skilled in the art upon a reading of the foregoing description. By way of example, using a single angel taper of just one of the two opposing rails instead of tapering both rails towards one another could improve the linearity of the weft at the shifted angle. Also, the addition of steam heated rolls at the exit of the drying range could improve stability and dryness following pin extraction on the tenter frame. It should be understood that all such modifications and improvements have been deleted herein for the sake of conciseness and readability but are properly within the scope of the following claims.

We claim:

1. A shifted angle woven fabric having warp yarns and weft yarns, wherein said weft yarns are shifted between about 110 degrees and about 125 degrees relative said warp yarns, wherein the crimp of said fabric is substantially equal in both the warp and weft directions, and wherein side-to-side variation in warp yarn crimp is negligible.

2. The shifted angle woven fabric according to claim **1**, wherein said fabric is shifted about 112 degrees.

3. The shifted angle woven fabric according to claim **1**, wherein the ratio of warp crimp to weft crimp of said fabric is between about 0.5 and about 1.5 when crimp is measured according to ASTM-3883-90.

4. The shifted angle woven fabric according to claim **3**, wherein the ratio of warp crimp to weft crimp of said fabric is about 0.9.

5. The shifted angle woven fabric according to claim **1**, wherein the crimp of said fabric is between about 3% and about 10% in both the warp and weft directions.

6. The shifted angle woven fabric according to claim **1**, wherein the elongation value of said fabric is between about 35% and about 55% when tested according to ASTM-5034-95.

7. The shifted angle woven fabric according to claim **6**, wherein the elongation value of said fabric is about 55%.

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